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Aggregate Resources Inventory Paper 68

AGGREGATE RESOURCES INVENTORY OF THE TOWNSHIP OF BLANDFORD-BLENHEIM

Oxford County

SOUTHERN ONTARIO

by
Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1983

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Deputy Minister

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

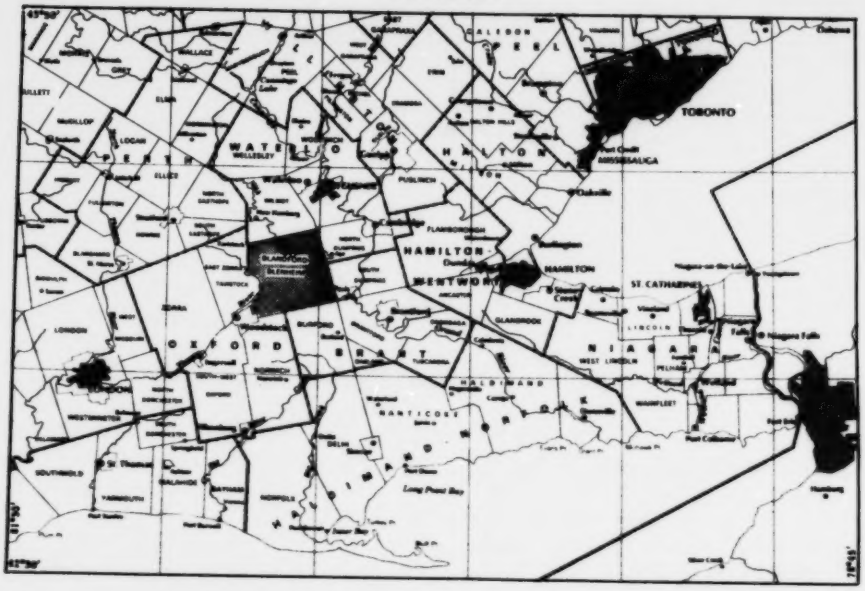

Figure 1 - Key Map Showing Location of the Township of Blandford-Blenheim, Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Township of Blandford-Blenheim. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

In the Township of Blandford-Blenheim seven areas containing sand and gravel have been selected for possible resource protection. The Selected Sand and Gravel Resource Areas of Primary Significance have a total of 2080 acres (840 ha), exclusive of licenced properties. An estimated 1410 acres (570 ha) are currently available for extraction, containing possible resources of 53 million tons (48 million tonnes). The available parts of the selected areas represent three percent of the total area occupied by sand and gravel deposits in the township and four percent of the total resource tonnage.

Generally the sand and gravel may be suitable for Granular Base Course A, B and C, and 5/8 inch (16 mm) crushed, and hot-laid aggregate products, although sand selection and blending may be required (Deike 1981). Chert is found in deposits throughout the township and beneficiation may also be required.

Four ice-contact stratified drift deposits and four outwash deposits have been suggested as Resource Areas of Secondary Significance.

The Township of Blandford-Blenheim has low to moderate possible sand and gravel resources which should be sufficient for local use in the near future. Therefore care should be taken to ensure the continuing availability of as much of the remaining resources as possible.

Bedrock underlying the township consists of dolomitic shale and dolostone of the Upper Silurian Salina and Bass Islands Formations, respectively. These formations are overlain by cherty limestone of the Lower Devonian Bois Blanc Formation and dolostone and limestone of the Middle Devonian Amherstburg Formation of the Detroit River Group. Generally the drift overlying the bedrock is greater than 100 feet (30 m) and exceeds 200 feet (61 m) in several localities. Thick drift prohibits the economic quarrying of bedrock, therefore no areas have been selected for possible resource protection.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE TOWNSHIP OF BLANDFORD-BLENHEIM[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1979, the total tonnage of mineral aggregates extracted was 144 million tons (131 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1980).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, November 25, 1982.
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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11 to 45 kg) units either from existing pit faces or from test pits dug by backhoe. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed by the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, drilling using a powered hollow stem auger was undertaken. The stratigraphic sections in these test holes are described in drill logs included in the report as Table 7. In some cases samples taken during the course of the drilling were analysed to determine grain size distribution. The symbols for and locations of test hole sites are noted on Map 1.

In the office, the pit and field sample data were supplemented by information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Soil reports published by the Ontario Ministry of Agriculture and Food were also consulted in order to supply additional information in areas with limited data. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data

such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2). Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas lying outside of licenced properties that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favorable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot (0.3 m) thick section of dolostone, one acre (0.4 ha) in extent, assuming a bulk density of 165 pounds per cubic foot (2649 kg per cubic metre)).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) or approximately 3200 tons per acre (7173 tonnes per hectare). Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

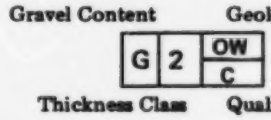
Map 1 is derived directly from the existing surficial geology maps of the area or from airphoto and field interpretation where surficial mapping is incomplete. It shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

The present level of extractive activity in the study area is indicated as follows. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are also identified and numbered on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit, as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, silt, and clay in the sampled material are shown graphically by the sub-

division of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a dark shading on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no shading. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indi-

cates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (or high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphaltic aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete or structures. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products — Granular Base Course A,B, and C; and Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but

readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three shades. The darkest shade indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and

Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWNSHIP OF BLANDFORD-BLENHEIM

LOCATION AND POPULATION

The Township of Blandford-Blenheim occupies an area of 96,289 acres (38 968 ha) in the northeastern section of Oxford County and is shown on portions of the Stratford (40 P/7), Cambridge (40 P/8), Brantford (40 P/1) and Woodstock (40 P/2) map sheets of the National Topographic System at a scale of 1:50 000. The township is bounded on the north by the Township of Wilmot; on the east by the townships of North Dumfries and South Dumfries; on the south by the townships of Burford and Norwich and on the west by the Township of East Zorra-Tavistock.

There are no major urban centres in the township, however important trade and retail centres are found within a short distance of the township. Woodstock lies on the southwestern corner of the township while the cities of Kitchener and Cambridge are located to the northeast, and Paris and Brantford are found to the southeast. Local service centres in the township include the hamlets of Plattsville, Bright, Drumbo and Princeton. Smaller settlements include Blandford, Ratho, Chesterfield, Washington, Wolverton, Richwood, Canning and Gobles.

In 1980 the population of the township was 6691, a 10 percent increase since 1972 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The majority of the population is rural-farm.

Road access in the township is provided by the King's Highway 401 which bisects the township. The King's Highway 2 forms the township's southern boundary. Additional access is supplied by a grid of paved county roads and gravel-surfaced township roads. The township is serviced by two lines of the Canadian National Railways, and one line of the Canadian Pacific Railway which runs east-west through the central portion of the township.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of surface material in the Township of Blandford-Blenheim are the result of glacial activity that occurred in the Late Wisconsinan Substage of the Pleistocene Epoch. This period of time, lasting from approximately 23 000 to 10 000 years ago, was marked by the repeated advance and melting back of the Laurentide continental ice sheet.

The Township of Blandford-Blenheim was subjected to glacial action by ice lobes occupying the Lake Ontario, Lake Erie and Lake Huron basins. The Waterloo Moraine (an interlobate moraine), also referred to as the Waterloo Hills (Chapman and Putnam 1966, p. 215), was probably created during the first stage of recession of the Ontario-Erie and Huron lobes. This feature lies north of King's Highway 401 and extends from Plattsville northward, incorporating the west-central part of the Regional Municipality of Waterloo. Chapman and Putnam (1966) describe the moraine as composed of sandy till, kames and kame moraines with outwash sands in the intervening hollows. Generally the texture of the Waterloo Moraine is sandy. Pockets of coarse aggregate are scattered throughout the area, but locating them may be difficult. The Nith River, a meltwater channel, generally marks the western boundary of the Waterloo Moraine.

Other features in the township are a series of end moraines: the Ingersoll; Norwich; and Tillsonburg moraines that were created as the Erie lobe receded, depositing the fine-grained silty Port Stanley Till (Cowan 1975). The Ingersoll Moraine, the westernmost moraine, can be traced in the township from Eastwood northeasterly to Drumbo and to just west of the Nith River near Ayr, in the Township of North Dumfries. The moraine is breached north of Gobles by Horner Creek.

The Norwich Moraine enters the Township of Blandford-Blenheim southeast of Princeton and continues northeasterly into North Dumfries, remaining south of the Nith River. Like the Ingersoll Moraine, it is a set of disconnected morainic hills separated by stream courses and often buried by lacustrine sand.

The Tillsonburg Moraine, the last in the series of end moraines crosses the southeast corner of the township. It also is fragmented, breached by water courses and often buried by glaciofluvial and lacustrine deposits. Drainage in the town-

ship is primarily controlled by the end moraine system (Cowan 1975).

There are two principal areas of ground moraine in the Township of Blandford-Blenheim. One area, in the northwest corner of the township lies within the physiographic region described by Chapman and Putnam (1966, p. 231) as the Oxford Till Plain. It is composed of the stony sandy silty Tavistock Till (equivalent to the Zorra till of Cowan 1975). The other ground moraine plain lies north and east of Princeton between Horner Creek and the Nith River. It is composed of the clayey silty Port Stanley Till (Cowan 1975). A meltwater channel crosses the plain between Richwood and Princeton, representing an ice-marginal position between the Ingersoll and Norwich moraines (Cowan 1975).

One of the main glacial features in the Township of Blandford-Blenheim is the large sheet of outwash sand, west of Blandford. Cowan (1975) suggests the sands were deposited simultaneously from the meltwaters of the Erie-Ontario and Huron ice lobes. The sand plain around Gobles is composed of outwash deposited in a re-entrant of the Erie lobe as it melted back from the Ingersoll Moraine to the Norwich Moraine (Cowan 1975). This large deposit forms part of the physiographic region described by Chapman and Putnam (1966, p. 251) as the Norfolk Sand Plain. Scattered pockets of outwash sand and gravel represent local deposition by meltwaters (Cowan 1975).

Associated with the outwash sand deposits are several groups of ice-contact stratified drift deposits. Cowan (1975, p. 40) describes the deposit northwest of Gobles as "pebbly to bouldery medium to fine sand with localized masses of sorted coarse sand and gravel." These deposits may provide useful sources of sand and gravel.

The Nith River and Horner Creek occupy abandoned meltwater channels (Cowan 1975). Outwash deposits found along the Nith River, especially in the southeastern part of the township, were derived from the glaciers that advanced from the east. These deposits may provide good sources of aggregate. Older alluvium along the Nith River consists of fine to medium gravel (Cowan 1975).

It is important to note that chert, a deleterious material, is found within sand and gravel deposits in the township. Generally the deposits northeast of the Canadian National Railways line which runs through Drumbo are chert free or contain only minor amounts of chert (1 to 3 percent). The deposits southwest of the line may have a chert content of 10 to 20 percent (Deike 1981).

EXTRACTIVE ACTIVITY

At least twenty-two sand and gravel pits have been opened in the Township of Blandford-Blenheim in the past. Many of the properties have become inactive since the designation of the township in 1975 under The Pits and Quarries Control Act, 1971. At the time of writing only eight sources were licenced for extraction. The total area licenced is 212.5 acres (86.0 ha).

Since designation of the township, records of the total annual production from all licenced pits have been maintained by the Aylmer and Cambridge District Offices of the Ministry of Natural Resources. The average annual production from all licenced sources between 1976 and 1980 has been 171,705 tons (155 771 tonnes). The average annual production from wayside sources (for which temporary permits rather than licences are required) between 1974 and 1979 has been 79,000 tons (72 000 tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS

In the Township of Blandford-Blenheim five ice-contact stratified drift deposits, two outwash deposits and an esker deposit have been selected for possible resource protection at the primary level. These deposits occupy a total of 2080 acres (840 ha), exclusive of licenced areas. Cultural constraints reduce the presently available area to 1410 acres (570 ha). Using average deposit thickness estimates for each resource area, the total sand and gravel resources are approximately 53 million tons (48 million tonnes). The Primary Resource Areas represent three percent of the total area occupied by sand and gravel deposits in the township and contain four percent of the total resource tonnage.

Chert, a deleterious material may be found throughout the township. Chert particles in the gravel are derived from bedrock lying west of the township. Chert from the Dundee and Bois Blanc Formations was incorporated into the Huron ice lobe and eventually deposited in

Blandford-Blenheim. Generally the selected areas in the northeast half of the township are chert free or contain only minor amounts (1 to 3 percent) of cherty material. Sand and gravel from these sources may be suitable for hot-laid aggregate products. Deposits in the southwestern half may contain 10 to 20 percent chert clasts. Aggregate processed from these areas may be unsuitable for hot-laid or structural concrete unless the material is beneficiated to remove the chert (Deike 1981). Excess silt and clay in Selected Areas 2, 3, 4 and 6a may hinder the use of the material for hot-laid and concrete aggregate (Deike 1981).

The areas selected for possible protection on Map 2 generally correspond to those selected by Cowan (Map 2282, 1975). Variations between the two maps are a result of the scale of investigation, and new information now available.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is an outwash deposit located southeast of Washington. The Area, a spillway deposit, was created when the Nith River served as a meltwater channel. There are two licenced properties (pit nos. 3 and 4) presently located in the Area. Faces in pit no. 3 are 12 to 15 feet (4 to 5 m) in height and expose well sorted medium to coarse sandy gravel and well graded sand. The material may be suitable for Granular Base Course (G.B.C.) A, B and C, 5/8 inch (16 mm) crushed A and B and some hot-laid aggregate products (Deike 1981).

Area 1 occupies a total of 450 acres (182 ha), exclusive of licenced areas. Cultural constraints reduce the area available for extraction to 390 acres (158 ha). Assuming an average thickness of 15 feet (5 m), the sand and gravel resources are approximately 15 million tons (14 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2, an ice-contact stratified drift deposit, is located north of Wolverton and is bisected by King's Highway 401. Gravel in this deposit is relatively chert free, containing 1 to 3 percent chert (Deike 1981). Faces in unlicenced pit no. 18 are 10 to 18 feet (3 to 6 m) in height and expose medium to coarse sand and gravel lenses. The material may be suitable for G.B.C. A, B and C, 5/8 inch (16 mm) crushed A and B and some hot-laid aggregate products, although beneficiation and sand control may be required (Deike 1981). Test hole BB-TH-3, drilled in the east half of the deposit revealed up to 20 feet (6 m) of sand and fine gravel. A test hole logged by the M.T.C. at pit 21 indicated sand overlying gravel. The material in the test pit may be used for crushed aggregate if sand control is performed (Deike 1981).

Area 2 occupies a total of 1070 acres (435 ha); cultural constraints reduce the available area to 600 acres (243 ha). Using an estimated deposit thickness of 15 feet (5 m), the available resource tonnage is approximately 22 million tons (20 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3, is an ice-contact stratified drift deposit, west of Selected Area 2. The aggregate of this deposit is similar to that in Area 2, whereby the chert content may be from 1 to 3 percent. Testing done by the M.T.C. at pit 22 indicates that the sand and gravel may be suitable for G.B.C. A, B and C, 5/8 inch (16 mm) crushed A and B and some hot-laid products. Sand control may be required for crushing and excess fines may hinder the use of some of the material for production of hot-laid aggregate (Deike 1981).

Area 3 occupies a total of 295 acres (119 ha), and cultural setbacks reduce the area available for extraction to 230 acres (93 ha). Using an estimated deposit thickness of 15 feet (5 m), the resource tonnage is approximately 9 million tons (8 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 is an ice-contact stratified drift deposit, north of Bright. The deposit is described in a report by Planning Initiatives (Puopolo, McLellan, Eagles and Associates Limited 1980) as a kame, subdivided into two parts. The upper part of the deposit consists of coarse material with interbedded sand layers while the underlying section contains sand. The faces in licenced pit no. 8 are 12 to 18 feet (4 to 6 m) in height. The material may be suitable for G.B.C. A, B and C, 5/8 inch (16 mm) crushed A and B and some hot-laid aggregate products although the sand often contains excessive silt and clay (Deike 1981).

Selected Area 4 occupies a total of 50 acres (20 ha), exclusive of the licenced property. Cultural setbacks reduce the available area to 35 acres (14 ha). Using an estimated deposit thickness of 15 feet (5 m) the available resource tonnage is approximately 1 million tons (1 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 5

Selected Sand and Gravel Resource Area 5 is an ice-contact stratified drift deposit located north of Area 3. The deposit is just north of the Nith River and may be related to the Waterloo Moraine and the associated meltwater channel which developed along the edge of the moraine. One pit (pit no. 7) is presently licenced for extraction in the Area. Faces in the pit, 10 to 30 feet (3 to 9 m) in height, expose silty fine to medium sand and medium to coarse gravel. The material may be suitable for G.B.C. A, B and C, 5/8 inch (16 mm) crushed A and B and some hot-laid aggregate products although sand control may be required (Deike 1981).

Selected Area 5 occupies a total of 30 acres (12 ha), exclusive of licenced areas. Cultural constraints reduce the area available for extraction to 25 acres (10 ha). Using an estimated deposit thickness of 15 feet (5 m), the available resource tonnage is approximately 1 million tons (1 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS 6a AND 6b

Selected Sand and Gravel Resource Area 6a, south of Blandford, includes two ice-contact stratified drift deposits which Cowan (1975) suggests may be an extension of the esker selected as Resource Area 6b. Presently there are two unlicenced pits (pit nos. 14 and 15) in Area 6a. Faces in the pits are 10 to 20 feet (3 to 6 m) in height, and expose fine to medium gravel with silty fine to coarse sand. The material may be suitable for G.B.C. A, B and C, and 5/8 inch (16 mm) crushed B although sand control may be required. Generally the material grades too dirty for hot-laid aggregate products (Deike 1981). The chert content may range up to 20 percent within the deposit, therefore beneficiation may be required (Deike 1981).

Selected Area 6a occupies a total of 90 acres (36 ha). Cultural setbacks reduce the area available for extraction to 60 acres (24 ha). Using an estimated deposit thickness of 15 feet (5 m), the available resource tonnage is approximately 2 million tons (2 million tonnes).

Selected Sand and Gravel Resource Area 6b is an esker deposit. There are no pit exposures in the deposit although the material is probably similar in nature to the ice-contact deposits in Area 6a and may be used for the same road construction aggregate products.

Area 6b occupies a total of 25 acres (10 ha). Using an estimated deposit thickness of 15 feet (5 m), the available resource tonnage is approximately 1 million tons (1 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 7

Selected Sand and Gravel Resource Area 7 is an outwash deposit located along the Nith River, in the southeast corner of the township. The deposit is a glaciofluvial outwash with some deltaic sequences. One pit (pit no. 5), is presently licenced for extraction in the deposit. Pit faces 20 to 25 feet (6 to 8 m) in height contain 35 to 50 percent gravel. The material may be suitable for G.B.C. B and C (Deike 1981).

Area 7 occupies 65 acres (26 ha), exclusive of the licenced property. Cultural setbacks reduce the available area to 45 acres (18 ha). Using an estimated deposit thickness of 20 feet (6 m), the resource tonnage is approximately 2 million tons (2 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Four undifferentiated ice-contact stratified drift and four outwash deposits have been suggested as Resource Areas of Secondary Significance.

Three of the outwash deposits are located along the Nith River in the eastern part of the township. These deposits are associated with the Nith River meltwater channel deposits. Subsurface drilling (test hole nos. BB-TH-7 and 8) revealed up to 25 feet (8 m) of clean fine to coarse sand and fine gravel in the outwash deposit near Wolverton, and 10 feet (3 m) of silty gravel in the deposit surrounding Richwood. The third outwash deposit extends south into Burford Township where several unlicenced pits have a 40 to 45 percent stone

content. The material from the three deposits may be suitable for G.B.C. A, B and C (Deike 1981).

The fourth secondary outwash deposit is located along the northern boundary of the township. Licenced pit 2, located in the deposit, exposes moderately sorted medium to coarse gravel. While the material is suitable for several aggregate products, the deposit is less than 10 feet (3 m) thick. As a result it has been selected at the secondary level.

The largest ice-contact stratified deposit recommended for resource protection at the secondary level, runs in a northeast-southwest direction through the central part of the township, being deposited by the ice in front of the Ingersoll Moraine. One pit (pit no. 16), located in the deposit has a 4- to 12-foot (1 to 4 m) face, showed silty fine to medium sand with lenses containing fine gravel. Subsurface drilling (test hole no. BB-TH-6) revealed 20 feet (6 m) of silty sand. The material may be suitable for G.B.C. A, B and C and 5/8 inch (16 mm) crushed B (Deike 1981). Further investigation would be useful to better define the extent and use of the resources.

The second ice-contact stratified drift deposit is located in the southwestern corner of the township south of the Thames River. One unlicenced pit (pit no. 13) has a face height of 10 to 15 feet (3 to 5 m) revealing silty sand with medium gravel lenses. There was considerable oversize material in the pit which may provide a source of coarse aggregate. The material may be suitable for G.B.C. A, B and C and 5/8 inch (16 mm) crushed B (Deike 1981).

The last two ice-contact stratified drift deposits are located south and northeast of Blandford. The deposit located south of Blandford was described by Cowan (1975) as being composed of fine to medium sand with pockets of coarser sand and gravel. Subsurface drilling (test hole no. BB-TH-13) revealed clean to silty, fine to coarse sand and fine gravel. The material may be suitable for G.B.C. A, B and C and 5/8 inch (16 mm) crushed B (Deike 1981). The other deposit northeast of Blandford may be an interlobate deposit created by the Huron and Erie ice lobes (Cowan 1975). Subsurface drilling (test hole no. BB-TH-5) revealed 25 feet (8 m) of silty fine to coarse sand. The material may be suitable for G.B.C. A, B and C and 5/8 inch (16 mm) crushed B (Deike 1981). Further investigation would be useful to better delineate the extent and uses of the resources.

BEDROCK GEOLOGY

The bedrock underlying the Township of Blandford-Blenheim consists of dolomitic shale and dolostone of the Upper Silurian Salina Formation and Bass Islands Formation, cherty limestone of the Lower Devonian Bois Blanc Formation and limestone and dolostone of the Middle Devonian Amherstburg Formation of the Detroit River Group (Sanford 1969). The formations dip gently to the southwest. Generally the drift overlying the bedrock is greater than 100 feet (30 m) and does exceed 200 feet (61 m) in several localities. However, in a narrow band along the Thames River, near Innerkip and the City of Woodstock, the drift thickness is less than 50 feet (15 m).

The Salina, the oldest formation in the township, consists of non-fossiliferous grey to greenish-grey shales and shaly dolomites with some salt, anhydrite and gypsum lenses (Hewitt 1972; Telford 1979a). Gypsum, mined at Drumbo, Caledonia and Hagersville is used in the manufacture of portland cement, in plaster to form wallboard, and in plaster casts in dental and medical work (Guillet 1964). Drift thickness over the Salina exceeds 150 to 200 feet (46 to 61 m). The formation has little value as a source of construction aggregate (Deike 1981), therefore the formation has not been considered for possible resource protection.

The Salina Formation is overlain by medium-bedded, brown, finely crystalline dolostone of the Bass Islands Formation which in turn is overlain by the medium-crystalline, highly fossiliferous cherty limestones of the Bois Blanc Formation (Telford 1979a). The Bass Islands Formation has been quarried at Innerkip for lime and crushed stone for railway ballast (Goudge 1938). The material from both the Bass Islands and Bois Blanc Formations may be suitable for G.B.C. A and sub-base aggregate. With selection the Bass Islands Formation may also be suitable for hot-mix paving and structural concrete uses (Deike 1981). Since the two formations are covered by thin drift only in a small band along the Thames River, no areas have been selected for resource protection.

The Detroit River Group overlies the Bois Blanc Formation. Two formations make up the

Detroit River Group: the Amherstburg Formation which is found in Blandford-Blenheim; and the Lucas Formation which is located to the west in the Beachville-Ingersoll area. The Lucas consists of high-calcium limestone which is the thickest, most uniform and purest limestone in Ontario (Hewitt and Vos 1972, p. 64). The Amherstburg Formation limestone, however, does not possess the purity of the Lucas (because of the presence of chert), and is not important as a source of lime. As a result, the Amherstburg has not been selected for resource protection.

SUMMARY

The Township of Blandford-Blenheim has low to moderate possible sand and gravel resources which should be sufficient for local use in the near future. Five undifferentiated ice-contact stratified drift deposits, two outwash deposits and an esker deposit have been selected at the primary level for resource protection. Several undifferentiated ice-contact stratified drift and outwash deposits have been selected for possible resource protection at the secondary level. Care should be taken to ensure the availability of these resource areas.

Possible bedrock resources in the township are limited by the thickness of the overlying drift and the suitability of the formations. Therefore most of the township's aggregate requirements must be satisfied by sand and gravel deposits.

Enquiries regarding the Aggregate Resources Inventory for the Township of Blandford-Blenheim should be directed to the Ontario Ministry of Natural Resources at the following locations. For the area covered by the former township of Blandford contact the Aylmer District Office, 353 Talbot Street West, Box 940, Ontario, N5H 2S8 (Tel. (519) 773-9241), or the Southwestern Region Geological Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431). For the area included in the former township of Blenheim contact the Cambridge District Office, Box 2186, Cambridge, Ontario, N3C 2W1 (Tel. (519) 658-9356) or the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWNSHIP OF BLANDFORD-BLENHEIM

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-IC	245 (99)	15 (14)
	G-OW	82 (33)	4 (4)
	S-OW	485 (196)	24 (22)
2	S-AL	30 (12)	1 (1)
	G-E	25 (10)	1 (1)
	G-IC	2800 (1130)	105 (95)
	S-IC	8500 (3450)	234 (212)
	S-LP	870 (350)	33 (30)
	G-OW	3750 (1520)	105 (95)
	S-OW	13,700 (5500)	445 (405)
3	S-AL	10 (4)	<1 (<1)
	G-IC	930 (375)	20 (18)
	S-IC	1850 (750)	32 (29)
	G-K	100 (40)	2 (2)
	S-LP	580 (235)	10 (9)
	G-OW	2200 (890)	44 (40)
	S-OW	6400 (2600)	130 (118)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWNSHIP OF BLANDFORD-BLENHEIM

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
4	S-AL	790 (320)	5 (4)
	G-IC	25 (10)	1 (1)
	S-IC	80 (32)	1 (1)
	S-LP	1090 (440)	11 (10)
	G-OW	130 (53)	1 (1)
	S-OW	370 (150)	5 (4)
		45,000 (18 200)	1230 (1120)

N.B. Minor variations in all tables are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF BLANDFORD-BLENHEIM

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	–	Weston Sararus	Pt. 2 & 3	14	22.9 (9.3)	unopened	
2	S11-68	Elmer R. Poll Transport Ltd.	Pt. 3	14	36.0 (14.6)	10 (3)	40
3	S11-13	Leslie Adamkiewicz	Pt. 5	11	11.4 (4.6)	12-15 (4-5)	55-60
4	–	Leslie Adamkiewicz	Pt. 5	11	36.9 (14.9)	unopened	
5	–	Marilyn Wheeler	Pt. 3	4	33.2 (13.4)	20-25 (6-8)	35-50
6	S11-103	Brethren of Early Christianity	Pt. 12	11	9.9 (4.0)	18 (6)	sand
7	S11-103	Community Farm	Pt. 14 & 15	11	12.2 (4.9)	10-30 (3-9)	55-60
8	S11-10	Bright Sand & Gravel Ltd.	Pt. 23 & 24	12	50.0 (20.2)	12-18 (4-6)	55-60
					212.5 (86.0)		
UNLICENCED PITS*							
9	S11-22	Evans	2	14 Blandford		8-15 (2-5)	30-35
10	–	Unknown	20	13		15-20 (5-6)	50-55
11	–	Unknown	24	10		10-12 (3-4)	sand
12	–	Schumach	2, 3	6 Blandford		10-12 (3-4)	25-35
13	W11-109	G. Gibson	12	3 Blandford		10-15 (3-5)	30

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF BLANDFORD-BLENHEIM

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
14	W11-77	Allison	22	5		10-20 (3-6)	45
15	W11-19	McGee	22	4		10-20 (3-6)	45-50
16	W11-116	G. Lang	17	6		4-12 (1-4)	25-30
17	G01-102	Helen Rodger	4	8		10-20 (3-6)	35
18	–	Unknown	10	10		10-18 (3-6)	55-60
19	S11-095	F. Lyons	11	12		6-10 (2-3)	30
20	S11-111	Hall	6	13		5-10 (2-3)	35
21	S11-77	Ofner	10	9		13-16 (4-5)	25
22	S11-97	Becker	14	10		15-20 (5-6)	50-60

* Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWNSHIP OF BLANDFORD-BLENHEIM

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	450 (182)	60 (24)	0 (0)	390 (158)	15 (5)	15 (14)
2	1070 (435)	460 (186)	5 (2)	600 (243)	15 (5)	22 (20)
3	295 (119)	60 (24)	5 (2)	230 (93)	15 (5)	9 (8)
4	50 (20)	15 (6)	0 (0)	35 (14)	15 (5)	1 (1)
5	30 (12)	5 (2)	0 (0)	25 (10)	15 (5)	1 (1)
6a	90 (36)	25 (10)	5 (2)	60 (24)	15 (5)	2 (2)
6b	25 (10)	0 (0)	0 (0)	25 (10)	15 (5)	1 (1)
7	65 (26)	20 (8)	0 (0)	45 (18)	20 (6)	2 (2)
	2080 (840)	640 (260)	15 (6)	1410 (570)		53 (48)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, TOWNSHIP OF BLANDFORD-BLENHEIM

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
25-50 (8-15)	Detroit River Group (Amherstburg Formation)	60 (18)	160 (65)	35 (32)
			160 (65)	35 (32)
3-25 (1-8)	Bois Blanc Formation	30 (9)	115 (46)	12 (11)
25-50 (8-15)		30 (9)	160 (65)	17 (15)
			275 (111)	29 (26)
3-25 (1-8)	Bass Islands Formation	55 (17)	175 (71)	35 (32)
25-50 (8-15)		55 (17)	530 (214)	105 (95)
			700 (285)	140 (127)
			1140 (460)	205 (186)

TABLE 5 | QUARRIES, TOWNSHIP OF BLANDFORD-BLENHEIM

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)

– NONE –

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWNSHIP OF BLANDFORD-BLENHEIM

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
– NONE –							

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-I

Location: Lot 23, Con. 6

Elevation: Approximately 980 feet (300 m) a.s.l.

Date: October 16, 1980

DEPTH feet (metres)	DESCRIPTION
5 (2)	medium clean sand and fine gravel; pebbles are subangular to subrounded
10 (3)	coarse clean sand and fine gravel; pebbles are mostly subrounded, some are subangular
15 (5)	lost sample twice; water present flushing hole
20 (6)	lost sample; drilling very quickly through the material
25 (8)	fine grey silt; drill went through this material very quickly

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-2

Location: Lot 7, Con. 7

Elevation: Approximately 975 feet (295 m) a.s.l.

Date: October 16, 1980

DEPTH feet (metres)	DESCRIPTION
5 (2)	light brown, clean fine to medium sand
10 (3)	dark brown medium sand
15 (5)	medium sand graded to coarser sand with subangular to subrounded pebbles
20 (6)	medium to coarse sand and fine gravel; pebbles are more rounded and 1 to 1.5 inches (2.5 to 3.75 cm) in diameter
25 (8)	very coarse sand and fine gravel; pebbles are subangular to rounded
30 (9)	dark grey clay with 2 pebbles in a full core barrel

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-3

Location: Lot 6, Con. 9

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: October 16, 1980

DEPTH feet (metres)	DESCRIPTION
5 (2)	medium sand and fine gravel; pebbles are angular to subangular
10 (3)	medium sand and fine gravel; pebbles are subrounded
15 (5)	brown medium sand graded to sand and fine gravel; pebbles are subangular to subrounded
20 (6)	same sand and fine gravel as above, overlying brown silt
25 (8)	brown silt with some clay (fissile) then back into a small band of medium sand then clay with sand and fine gravel; the latter material is till-like

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-4

Location: Lot 20, Con.7

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	grey laminated silty fine to medium sand
10 (3)	coarse sand overlying fine gravel with subrounded pebbles; some silt is present; a piece of chert was found in sample
15 (5)	fine clean gravel with occasional subangular to subrounded pebbles; mostly limestone and dolomite, some chert
20 (6)	medium to coarse sand; small piece of chert; small sample of grey silt at the base of the core barrel
25 (8)	grey homogeneous silt
30 (9)	grey stony sandy silty till

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-5

Location: Lot 20, Con. 8

Elevation: Approximately 1025 feet (312 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	brown fine to medium sand; at base of core barrel was brown silty fine sand
10 (3)	brown silty fine to medium sand with occasional subangular pebbles
15 (5)	brown silty medium sand with a brown silt seam which contained a granitic pebble; brown silt at the base of the core barrel
20 (6)	silty coarse sand with occasional angular pebbles
25 (8)	clean coarse sand
30 (9)	brown homogeneous silt; brown fine sand and brown silt were found at the base of the core barrel

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-6

Location: Lot 15, Con. 7

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	light brown faintly laminated silty fine sand
10 (3)	light brown fine sand over brown silty fine sand; small bands of brown silt; some cross-bedding in fine sand but not very distinct
15 (5)	approximately 4 feet (1.2 m) of reddish brown silt over silty fine to medium sand; faint lamination in the silt
20 (6)	cross-bedded coarse sand with occasional subangular pebbles
25 (8)	reddish brown silt, with a small medium sand band overlying more of the same reddish brown silt

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-7

Location: Lot 6, Con. 8

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	clean coarse sand with occasional subangular to subrounded pebbles
10 (3)	clean fine gravel with subangular to subrounded pebbles; occasional granitic pebbles
15 (5)	brown clean coarse sand
20 (6)	brown clean coarse sand with occasional subangular to subrounded pebbles
25 (8)	brown silty fine sand with occasional subangular to subrounded pebbles
30 (9)	light brown stony sandy silty till grey till at base of the core barrel which may be another till

Test Hole Number: BB-TH-8

Location: Lot 6, Con. 4

Elevation: Approximately 925 feet (280 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	silty fine gravel with subangular to subrounded pebbles
10 (3)	silty medium gravel with subangular to subrounded pebbles
15 (5)	medium to coarse sand overlying reddish brown stony silty till
20 (6)	grey gritty silty clay till

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-9

Location: Lot 14, Con. 1

Elevation: Approximately 925 feet (280 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	silty medium to coarse sand with subangular medium gravel
10 (3)	approximately 3 feet(0.9 m) of sand and gravel over light brown homogeneous silt
15 (5)	light brown homogeneous silt

Test Hole Number: BB-TH-10

Location: Lot 22, Con. 2

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: January 14, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	light brown sandy silt
10 (3)	grey homogeneous silt
15 (5)	grey gritty till

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-11

Location: Lot 22, Con. 3

Elevation: Approximately 975 feet (295 m) a.s.l.

Date: February 4, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	reddish brown silty fine sand (oxidized)
10 (3)	reddish brown stony clay till
15 (5)	grey stony clay till
20 (6)	brown stony silty sand; stones are angular
25 (8)	large stone no sample
30 (9)	very angular fine gravel

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-12

Location: Lot 23, Con. 7

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: February 6, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	light brown clean fine sand with occasional angular to subangular pebbles
10 (3)	light brown silty fine to medium sand with angular to subrounded pebbles
15 (5)	light brown faintly laminated silty fine sand
20 (6)	light brown faintly laminated slightly silty fine sand
25 (8)	light brown silty fine sand over grey clean fine sand
30 (9)	light grey clean fine sand over brown silty fine sand; distinctly laminated

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWNSHIP OF BLANDFORD-BLENHEIM

Test Hole Number: BB-TH-13

Location: Lot 24, Con. 5

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: February 6, 1981

DEPTH feet (metres)	DESCRIPTION
5 (2)	sandy band then reddish brown clay till
10 (3)	silty fine gravel with subangular to subrounded pebbles
15 (5)	grey clean medium sand
20 (6)	brown stony silty sand; stones were subangular; sample taken off auger because the material was very wet

Test Hole Number: BB-TH-14

Location: Lot 22, Con. 9

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: February 6, 1981

DEPTH feet (metres)	DESCRIPTION
5-10 (2-3)	brown clay till; occasional granitic pebbles
15 (5)	grey clay till

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalies of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CAMBRIAN

The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited

in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2, 6 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SILURIAN

An early period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN DEPOSITS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS

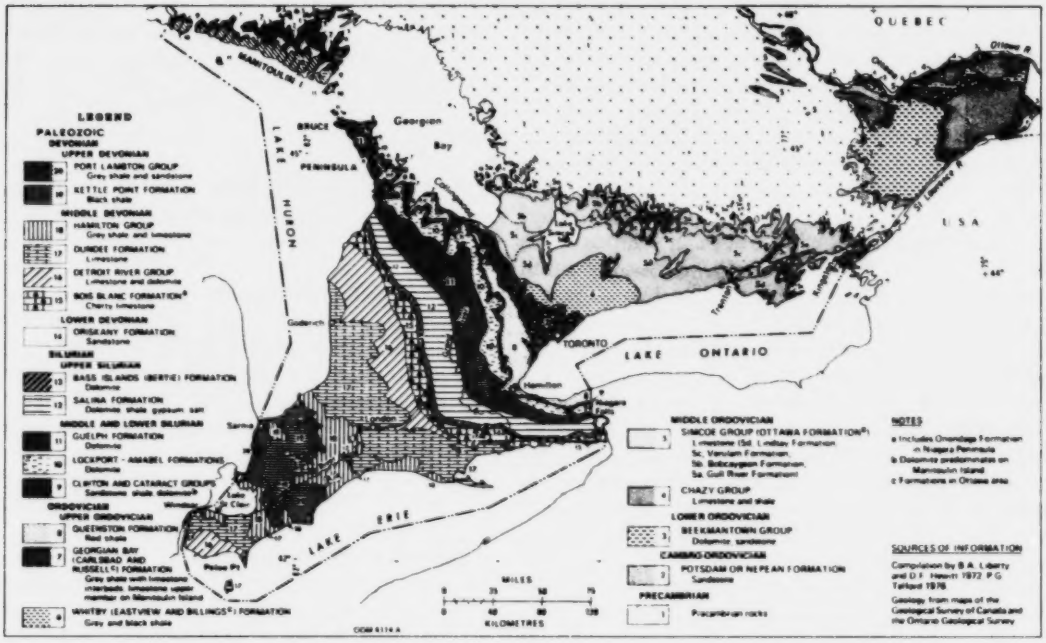

Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone.

Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for

crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular-weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for cement. The formation is unsuitable for crushed stone due to clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in Metro Toronto and Cooksville produce brick and structural tile. Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum.

The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto) Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.

R.M. OF WATERLOO
OXFORD CO
TP. OF WILMOT
TP. OF BLANDFORD-BLENHEIM
TP. OF BLANDFORD-BLENHEIM
OXFORD CO.
TP. OF EAST ZORRA-TAVISTOCK
OXFORD CO.
Chesterfield
Bright
Ratho
Plattsville
Washington
Wolverton
Drumbo
Orchard
Orchards
Sewage
Silo
Windpump
Dyke
Ditch
Greenhouse
Kilns
Control Valve
Transformer Station
Gas Pipeline (underground)
Oil Pipeline (underground)
Spring
Sluice Gate
Airfield
Sports Track
Poultry Farm
Creek
RIVER
CANADIAN NATIONAL
97
401
XIV
XIII
XII
XI
X
IX
VIII
VII
1118
1061
1028
1009
1006
1002
972
961
925
912

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF BLANDFORD-BLENHEIM
OXFORD COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/1 40 P/7
40 P/2 40 P/8

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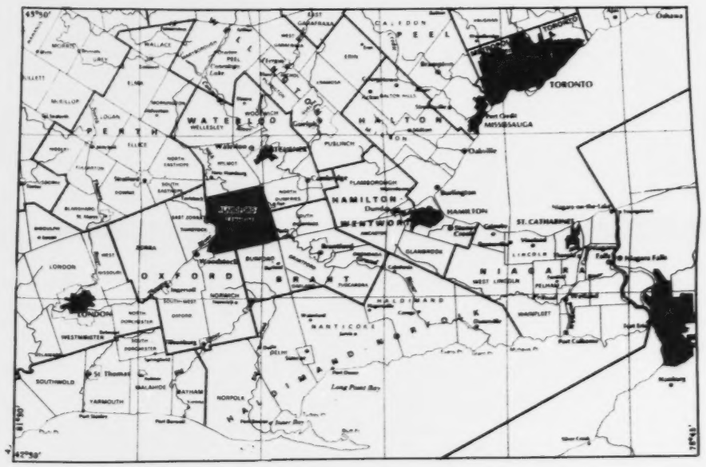


SYMBOLS

(Some symbols may not apply to this map.)

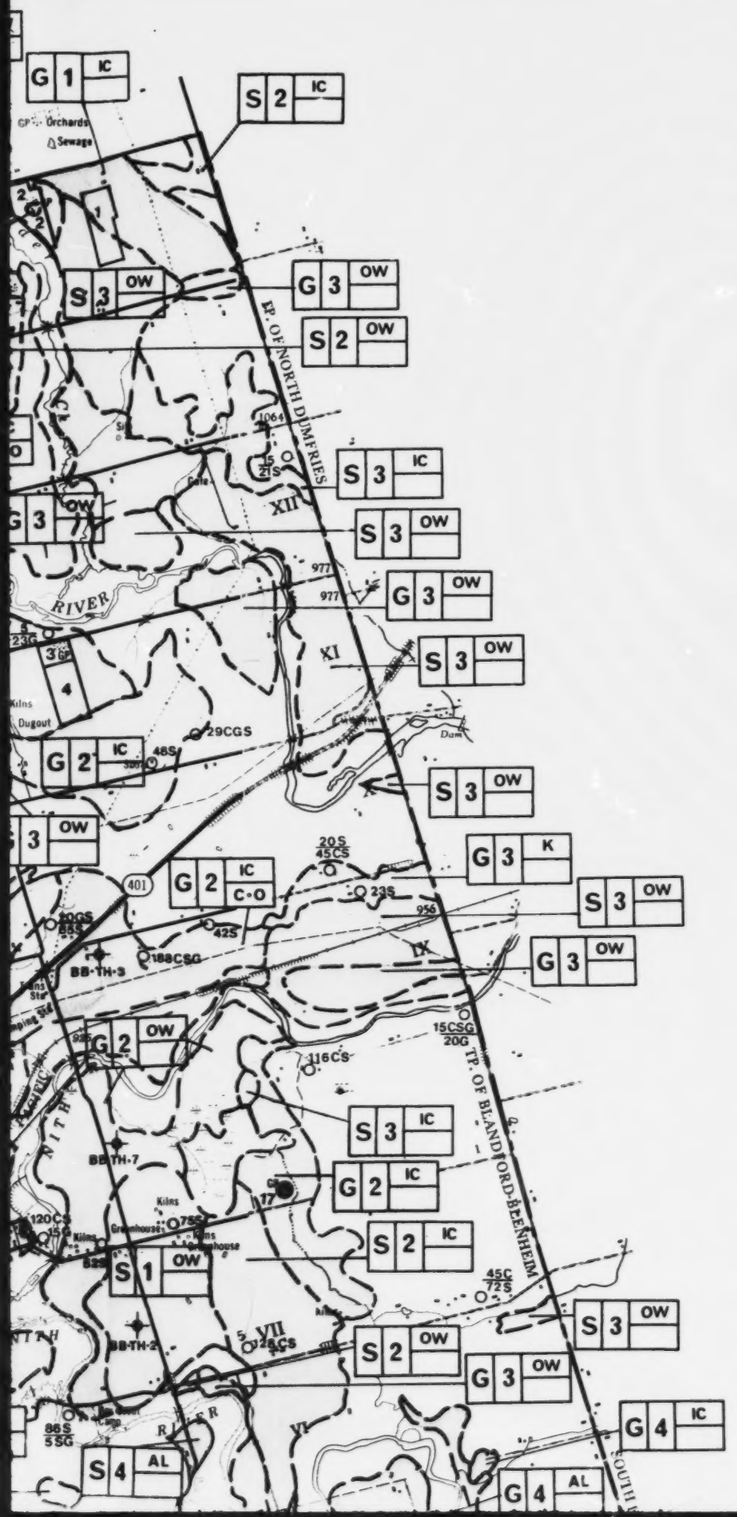
Geological and aggregate thickness boundary.

Buried geological and aggregate thickness boundary.

Municipal boundary.

(2) Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.

R. M. OF WATERLOO
OXFORD CO
TP. OF WILMOT
TP. OF BLANDFORD-BLENHEIM
TP. OF EAST ZORRA-TAVISTOCK
OXFORD CO
TP. OF BLANDFORD-BLENHEIM
Plattsville
Chesterfield
Bright
Drumbo
Orchard
Greenhouse
Kilns
Dugout
Sewage
Silo
Windpump
Transformer Station
Gas Pipeline (underground)
Oil Pipeline (underground)
Spring
Airfield
Poultry Farm
Control Valve
Dyke
Ditch
Quarry
Cemetery
Campground
Mac Donald-Cartier Freeway
CANADIAN NATIONAL RAILWAY
CANADIAN PACIFIC RAILWAY
Thames River
Black River
Nith River
Nith
Nith River
Nith
Nith
Nith



Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF BLANDFORD-BLENHEIM
OXFORD COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/1 40 P/7
40 P/2 40 P/8

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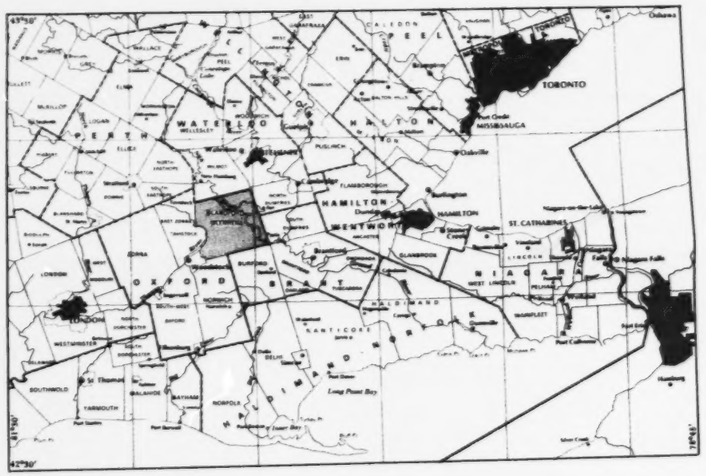


SYMBOLS

(Some symbols may not apply to this map.)

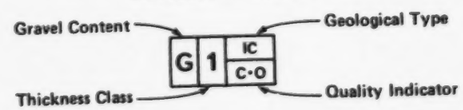
Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

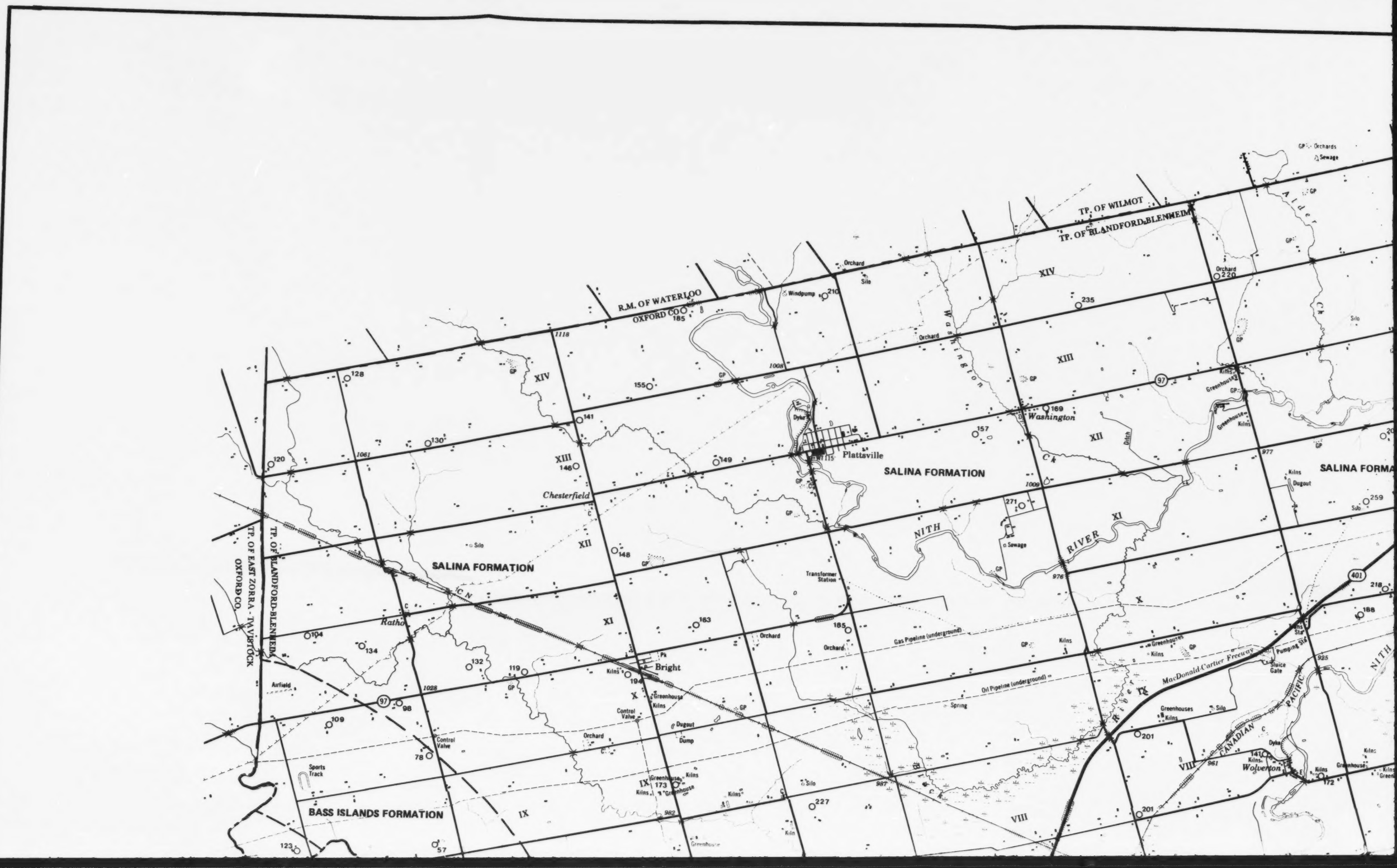
Municipal boundary.

Licenced property boundary; Property number: see

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve.). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.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TP. OF BLANDFORD-BLENHEIM
R.M. OF WATERLOO
OXFORD CO.
TP. OF EAST ZORRA - TAVISTOCK
OXFORD CO.
TP. OF BLANDFORD-BLENHEIM
Plattsville
Washington
Chesterfield
Bright
Wolverton
SALINA FORMATION
BASS ISLANDS FORMATION
NITH RIVER
MacDonald-Cartier Freeway
CANADIAN PACIFIC
C N
Orchard
Sewage
Silo
Windpump
Transformer Station
Gas Pipeline (underground)
Oil Pipeline (underground)
Greenhouses
Kilns
Dugout
Sports Track
Airfield
Control Valve
Pumping Sta
Sluice Gate
Dyke
Spring
Dump
Subs
XIV
XIII
XII
XI
X
IX
VIII
97
401

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWNSHIP OF BLANDFORD-BLENHEIM
OXFORD COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/1 40 P/7
40 P/2 40 P/8

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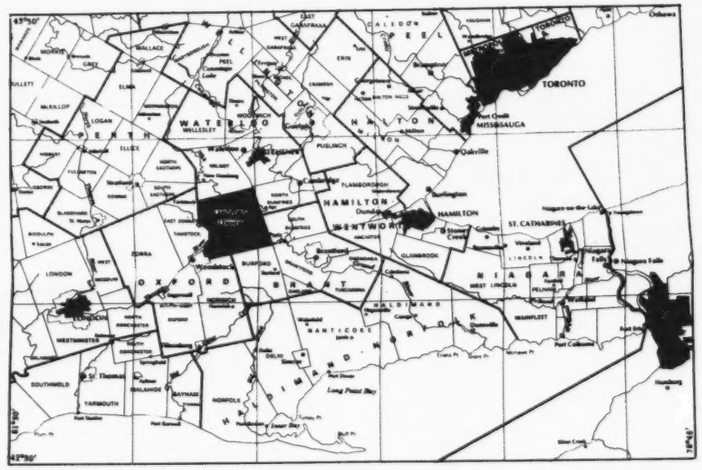


LEGEND

PALEOZOIC

DEVONIAN

MIDDLE DEVONIAN

DETROIT RIVER GROUP

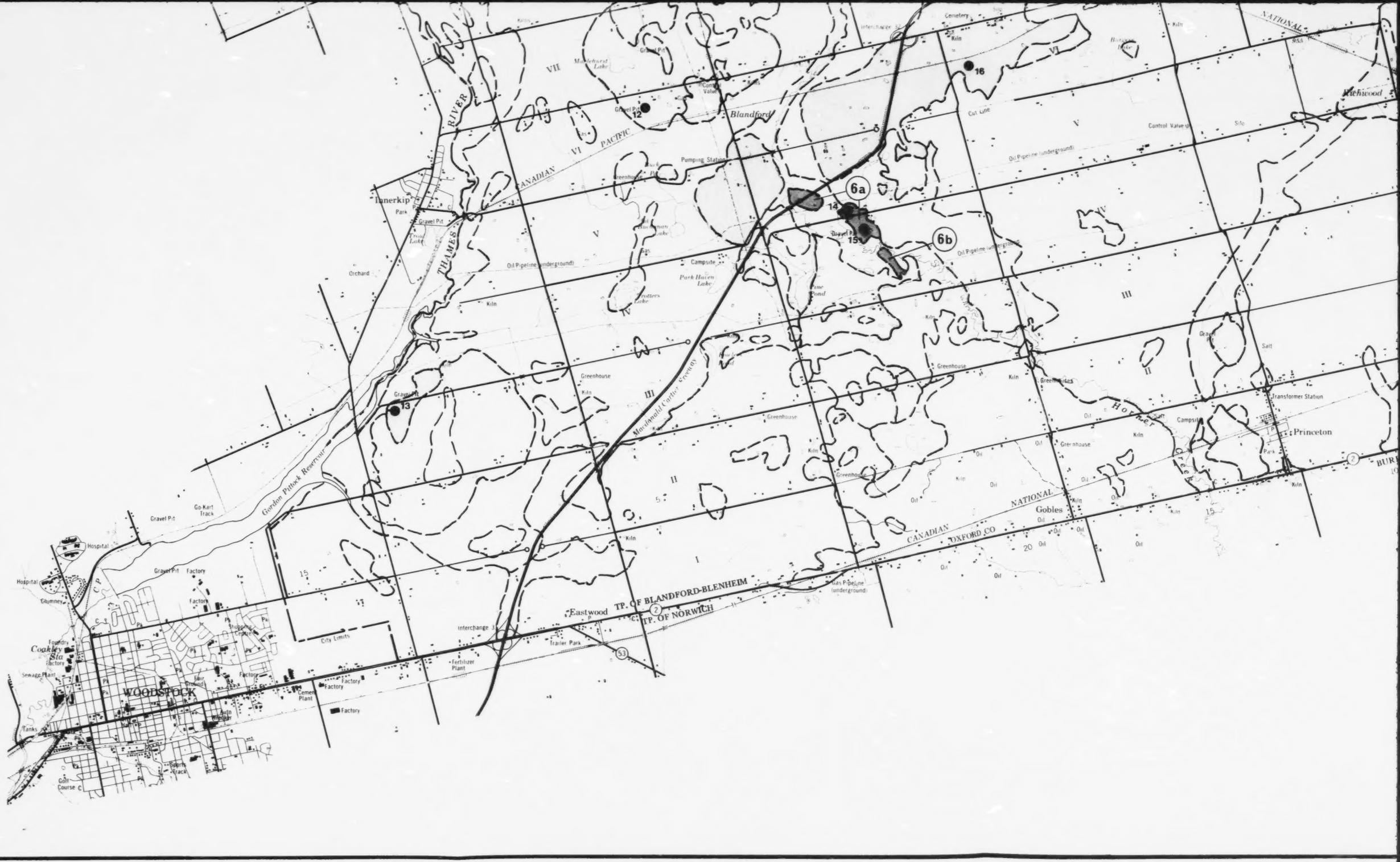
LUCAS FORMATION
Limestone

AMHERSTBURG FORMATION
Limestone and dolostone

LOWER DEVONIAN

BOIS BLANC FORMATION
Cherty limestone

SILURIAN


RIVER
THAMES
CANADIAN PACIFIC
Ingersoll
Park
Gravel Pit
Trout Lake
Orchard
Blandford
Pumping Station
Oil Pipeline (underground)
Campsite
Park Haven Lake
Critters Lake
Kiln
Greenhouse
Gravel Pit
13
12
16
14
15
6a
6b
VII
VI
V
IV
III
II
I
Meadowood Lake
Mud Lake
Bog
Lime Pond
Cut Line
Control Valve
Site
Richwood
Transformer Station
Princeton
Park
Salt
Greenhouses
Hoover
Gobles
NATIONAL
CANADIAN
OXFORD CO
20
15
Gordon Pittock Reservoir
Go-Kart Track
Hospital
Chimney
Factory
Shopping Centre
Foundry
Coakley Sts
Sewage Plant
WOODSTOCK
Tanks
Sports Track
Golf Course
City Limits
Interchange 4
Cement Plant
Fertilizer Plant
Trailer Park
Eastwood
TP. OF BLANDFORD-BLENHEIM
TP. OF NORWICH
Gas Pipeline (underground)
MacDonald Cartier Freeway
2
53
17

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Geology by: W.R. Cowan, 1972; 1975.
P.F. Karrow, 1971, in prep.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 68.

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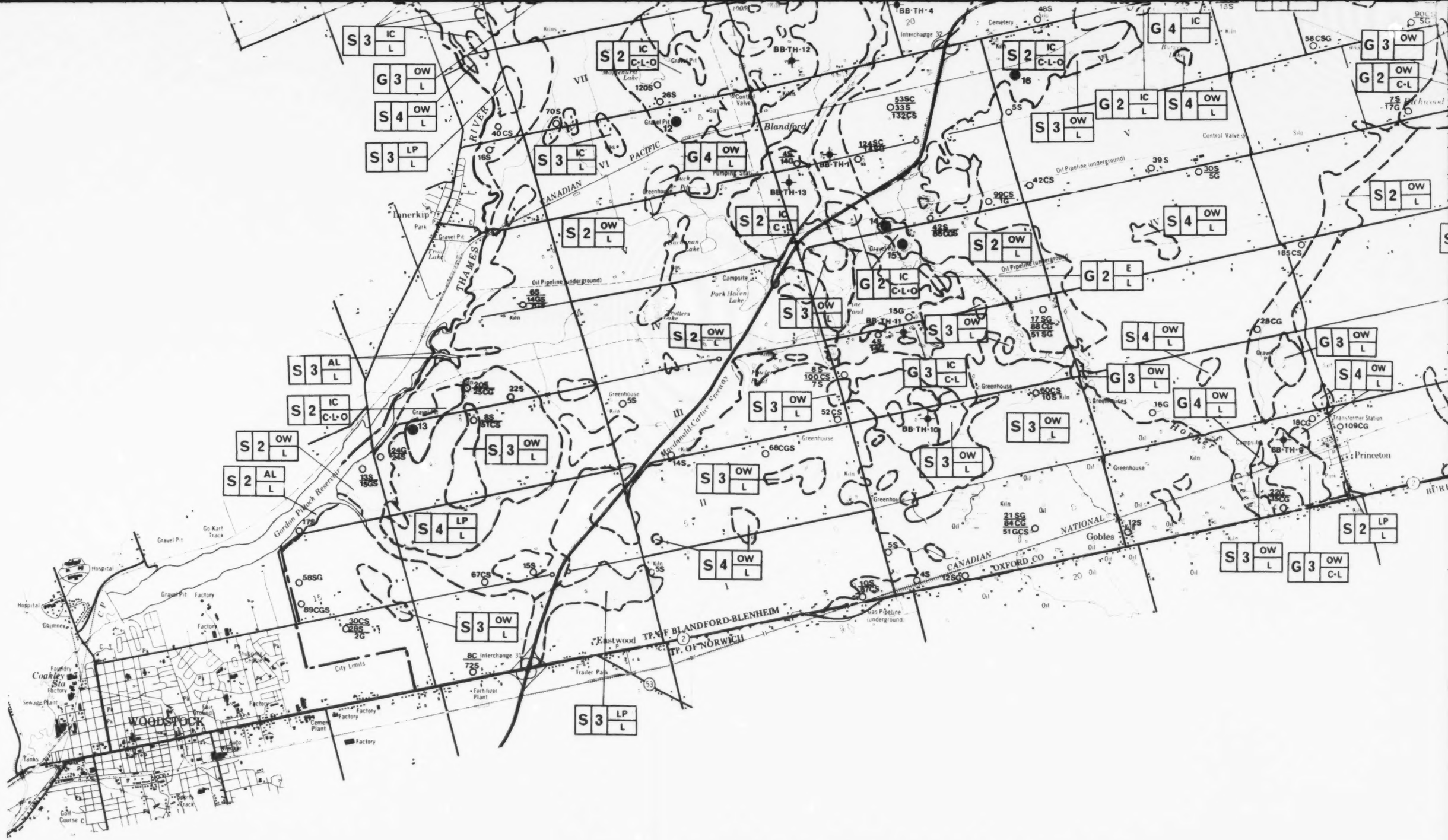
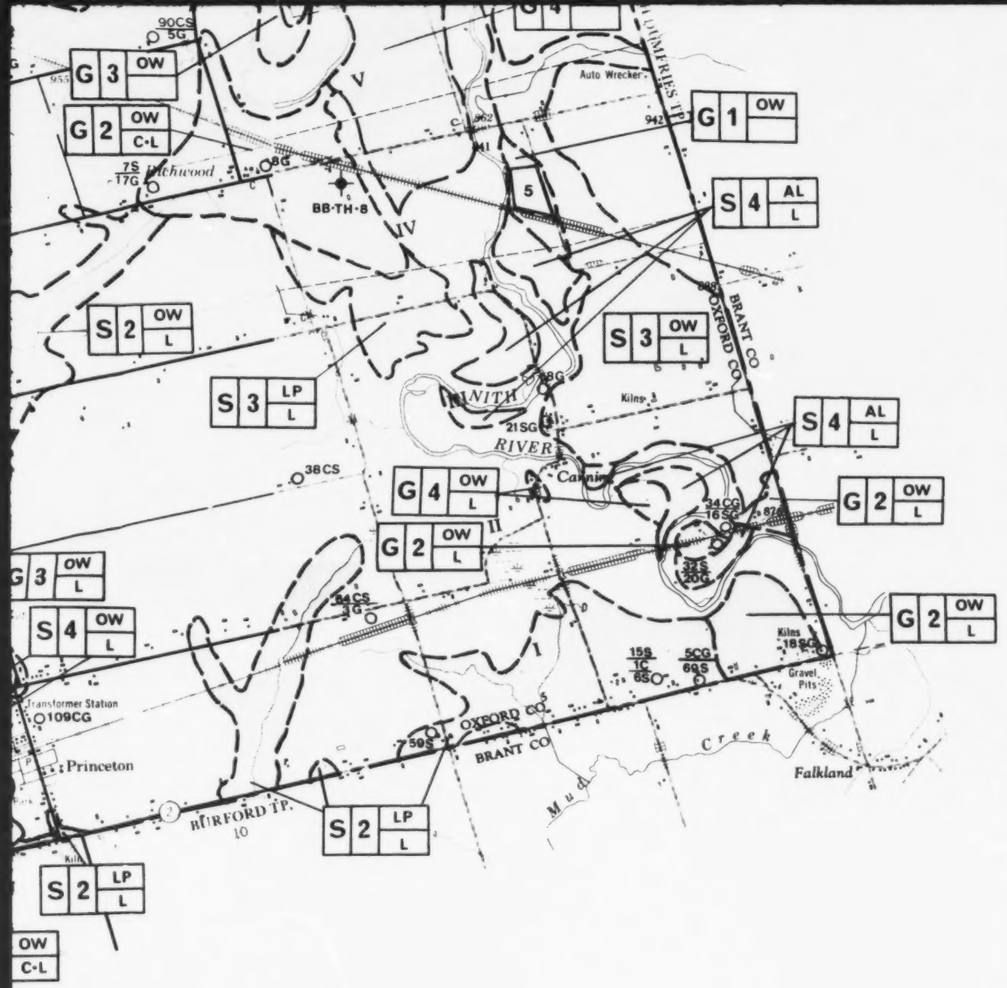
Issued 1983.


S 3 IC L
G 3 OW L
S 4 OW L
S 3 LP L
S 2 IC C-L-O
S 2 OW L
S 3 AL L
S 2 AL L
S 4 LP L
G 4 OW L
G 2 IC C-L
G 2 IC C-L-O
S 3 OW L
S 4 OW L
G 2 IC L
G 4 IC
G 3 OW C-L
G 2 E L
G 3 IC C-L
S 2 LP L
G 3 OW
S 2 OW
G 2 OW C-L
S 3 OW C-L
BB-TH-1
BB-TH-4
BB-TH-9
BB-TH-10
BB-TH-11
BB-TH-12
BB-TH-13
Blandford
Princeton
Gobles
Eastwood
Tanerkip
Park Haven Lake
Gordon Pittock Reservoir
Macdonald Cartier Freeway
Interchange 32
Interchange 31
Gravel Pit
Oil Pipeline (underground)
Gas Pipeline (underground)
Campsite
Greenhouse
Kiln
Factory
Hospital
Trailer Park
Fertilizer Plant
City Limits
Cemetery
Transformer Station
Control Valve
Pumping Station
Go Kart Track
Golf Course
Tanks
Sewage Plant
Coakley Sta
WOODSTOCK
TP. OF BLANDFORD-BLENHEIM
TP. OF NORWICH
OXFORD CO
CANADIAN NATIONAL
CANADIAN PACIFIC
THAMES RIVER



BLANDFORD—BLENHEIM

2 — Licenced property boundary. Property number: see Table 2.

● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

BB-TH-2 — Selected test hole location; Identification number: see Table 7.

6 / 23 G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC C-O — Deposit Symbol: see below.

Texture symbol: see below.

TEXTURE SYMBOL

The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G Greater than 35% gravel.
S Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	K	Kame
E	Esker	LB	Lacustrine Beach
EM	End Moraine	LD	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	LP	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	WD	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.
C Clay and/or silt (fines) present in objectionable quantities.
L Deleterious lithologies present.
O Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.
Selected drilled water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: W.R. Cowan, 1972; 1975.
P.F. Karrow, 1971, in prep.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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Issued 1983.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.

BASS ISLANDS FORMATION

BOIS BLANC FORMATION

DETROIT RIVER GROUP
AMHERSTBURG FORMATION

SALINA FORMATION

TP. OF BLANDFORD-BLENHEIM

TP. OF NORWICH

BURFORD TP.

Blandford

Eastwood

Princeton

Gobles

Innerkip

Woodstock

Richwood

Horner Creek

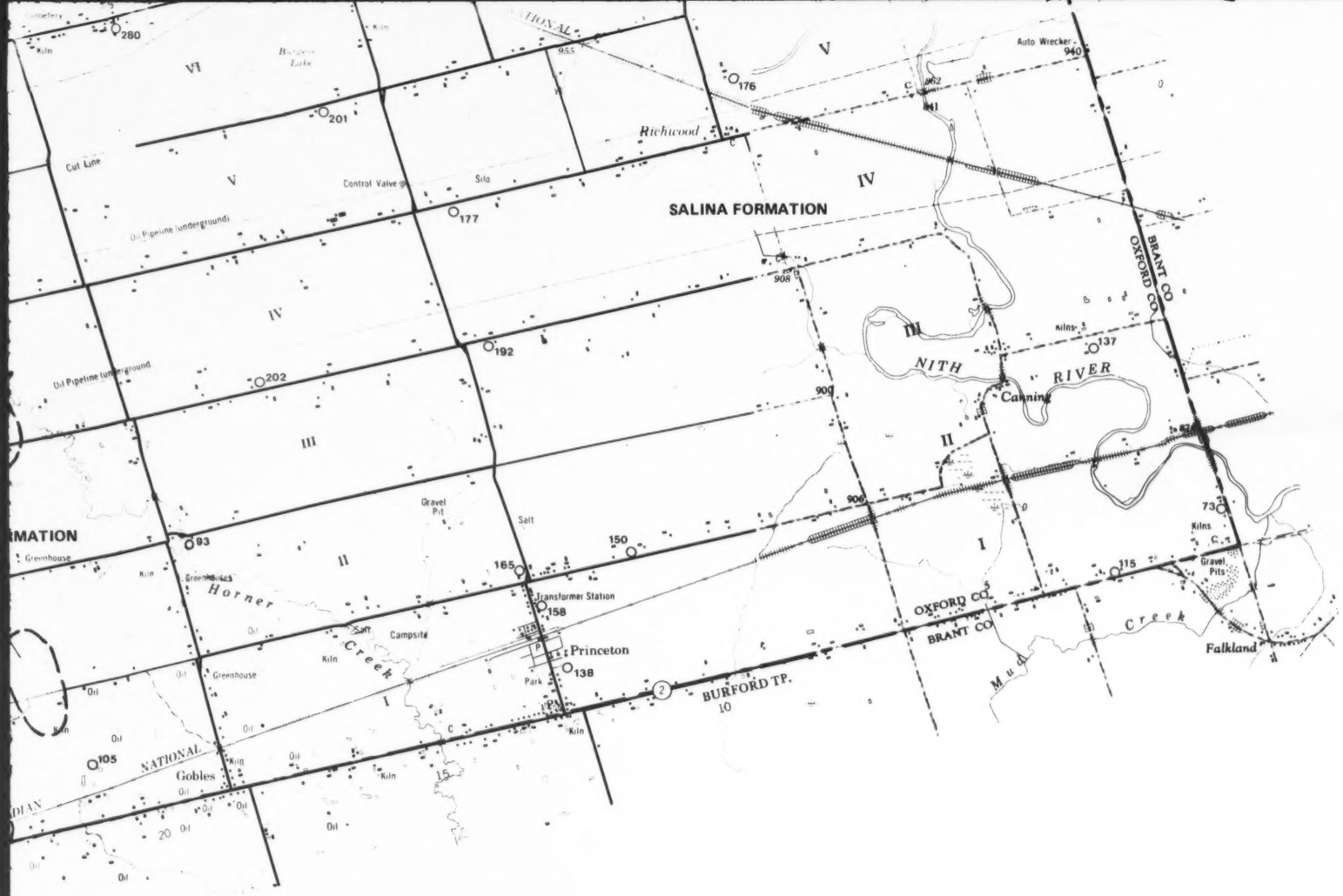
Thames River

Gordon Pittock Reservoir

Canadian National

Canadian Pacific

Macdonald Cartier Freeway



BLANDFORD–BLENHEIM

BASS ISLANDS FORMATION
Dolostone

SALINA FORMATION
Dolostone, shale, gypsum, salt

SYMBOLS

(Some symbols may not apply to this map.)

- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour: 25 foot (8 m) interval.
- Municipal boundary.
- 2 — Selected bedrock resource area; Deposit number: see Table 6.
- Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.
- Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.
- x — Isolated bedrock outcrop.
- Q2 — Licenced quarry boundary; Property number: see Table 5.
- Q3 — Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- 28 — Selected drilled waterwell location; reported depth to bedrock (in feet).

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Geology by: B.V. Sanford, 1969.
P.G. Telford, 1979a, b.

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